Overcoming complexities in controlling the world's largest PV-diesel hybrid plant

The Al Shamal Cement Plant PV power project in Sudan, designed by Mustakbal Clean Tech, is a landmark in renewable energy. With a capacity of 54.1 MW of photovoltaic power, it's the world's largest PV-diesel hybrid power plant, demonstrating the transformative potential of renewable energy. Integrating diesel generators and a massive PV array posed significant engineering challenges. Gantner's advanced control logic, managing 61 operating scenarios, ensures efficient, reliable, and safe plant operation. The project highlights innovation and adaptability, paving the way for a sustainable future in Sudan, showcasing the power of renewable energy to drive economic growth and combat climate change.

In the arid landscapes of Sudan, where the relentless sun beats down with unyielding intensity, stands a symbol of innovation and resilience: the Al Shamal Cement Plant PV power project. Built by international EPC Mustakbal Clean Tech, this monumental undertaking is not only a triumph of engineering, but also a testament to the transformative potential of renewable energy.

With an installed capacity of 54.1 MW of PV power, it is the world's largest PV-diesel hybrid power plant, lighting the way to a more sustainable future. But behind this impressive achievement lies a story of complex challenges and ingenious solutions that have transformed Sudan's energy landscape.

Integrating five diesel gensets with a combined output of 18.51 MW with a massive 54.1 MW PV array was a daunting task. Add to this the complexities of managing two limited-capacity grid connection points and ensuring the cement factory's uninterrupted and safe operation, and the scale of the challenge becomes clear. But it was precisely these challenges that spurred Gantner's engineering team to push the boundaries of innovation and redefine what's possible in renewable energy integration.

Customised control logic for 61 operating scenarios with Gantner PPC

Gantner developed bespoke control logic to meet the specific requirements of the project. Every facet, from the state of each switchgear to the current load of the cement plant, was meticulously analysed and considered. The result was a staggering 61 operating scenarios with different control logic, each carefully designed to optimise efficiency, ensure safety and guarantee reliability. Taking into account factors such as the load limits of the transformers and the export limits of each grid connection point, our solution ensures seamless operation under a wide range of conditions. Specific limitations apply to certain maintenance modes of certain parts of the switchgear.

Modern control solution with fixed sequences and timings

Central to the success of the Al Shamal Cement Plant PV power project is the Gantner Q.reader Power Plant Controller (PPC), which serves as the heart of the operation. This advanced system orchestrates the entire energy flow, ensuring flawless transition between energy sources and consumers.

In addition, interactive HMI screens provide on-site personnel with real-time insight into the operation of the switchgear, enabling

them to make informed decisions. Gantner's highly encrypted remote access system, Gantner.RAS, allows all system functions to be controlled or adjusted remotely.

The hybrid power plant generates large amounts of data about PV module performance, weather conditions, diesel gensets and grid integration. Managing and analysing this data requires advanced data management and analysis tools. Gantner.webportal is a cloud-based SaaS or on-premises big data analytics solution that processes millions of measured and calculated values per minute.

The digital twin feature of Gantner.webportal allows users to create a virtual replica of the power plant with the Mechanistic Power Model (MPM), which includes advanced analytics tools to enable deeper analysis and unlock the full potential of the power plant. For example, predictive maintenance can be performed by analysing historical data on equipment performance and environmental conditions using state-of-the-art AI techniques.

Such algorithms can be trained to predict when components are likely to fail or require maintenance. This allows the plant operator to proactively schedule maintenance, avoiding costly unplanned downtime and maximising equipment life. Power plants require regular maintenance and repair to ensure optimum performance.

Managing maintenance schedules, identifying faulty components and efficiently scheduling repairs can be complex due to the size of the plant and the need for coordination between multiple stakeholders. Features such as O&M planning, ticketing and asset inventory help users to efficiently perform these tasks.

An alarm overview screen allows the safe operation of the complex system to be monitored. In addition, fail-safe control logic implementations mitigate the risk of communication loss or cable breakage for each measurement instrument and switchgear status, protecting against potential disruptions.

The Gantner PPC is certified for grid connection up to extra-high voltage, 300 kV to 750 kV, meeting international standards and national grid code requirements. It has a proven track record in demanding systems where, in addition to PV power, battery storage and other energy sources such as wind power need to be controlled.

Dynamic operation: the adaptive power system of the Al Shamal Cement Plant PV Power Project

What sets our solution apart is its unparalleled adaptability. The Al Shamal Cement Plant PV power project isn't just a static installation; it's a dynamic ecosystem capable of seamlessly switching between pure PV mode connected to one or both connection points, and PV-diesel hybrid mode connected to one or both connection points. It accommodates maintenance requirements without missing a beat. This flexibility, enabled by robust control algorithms, ensures optimal performance in all circumstances.

Benefits of Gantner's scalable and robust DAQ architecture

Working exclusively on large utility scale projects, Gantner has gained extensive knowledge and expertise in this area over the last 13 years. Several hundred projects have resulted in a standard architecture for independent third-party monitoring and control of such projects. Dozens of gigawatts of PV systems have been successfully equipped with this design in recent years.

The architecture is based on the use of specialised data logging cabinets, known as Field Point Extensions, at each key point of the PV system, containing all the technology for monitoring and control. At the Al Shamal Cement Plant PV power project, these cabinets are specifically designed to facilitate the seamless integration of data from various sources within the power plant infrastructure, such as substations, switchgear and the diesel generators.

The complete solution includes data loggers, power plant controllers, active network technology and sensors and is optimised for demanding monitoring, power plant control and data security requirements.

A standardised monitoring and control layout for all power plants, regardless of inverters, transformers, medium voltage stations, etc., is important to enable easy maintenance and service over the entire lifetime of the asset.

In addition to data collected from transformers, switchgear and the diesel generator area, the Gantner PPC also relies on information from five weather stations. These weather stations play a vital role in providing the critical meteorological data needed to ensure the efficient and optimal performance of the power plant. By utilising this extensive network of data acquisition points, the Gantner PPC enables operators to make informed decisions, monitor the status of critical components and effectively manage the overall operation of the plant.

In common with other international projects, the Al Shamal Cement Plant project is concerned with increasing cyber security requirements. The Gantner solution meets the highest cyber security standards by providing tools for continuous network monitoring and health monitoring. As an ISO 27001 certified company, Gantner also offers the option of service level agreements to meet the customer's individual requirements.

With a Q.reader update in Q4/2024, the network connection between all Gantner components in the entire system will be secured with an encrypted connection.

In addition, the Gantner architecture has distributed failover and redundancy features.

Solar power lights the way to a sustainable future for Sudan

Beyond its technical complexities, the Al Shamal Cement Plant PV power project has profound implications for Sudan and the wider region. By harnessing the abundant sunlight that bathes the country's landscape, we're not only generating electricity, we're paving the way for a more sustainable future. The project is a beacon of hope, demonstrating the potential of renewable energy to drive economic growth, create jobs and mitigate the effects of climate change.

In the harsh, unforgiving terrain of Sudan, where every drop of water and ray of sunlight holds the promise of progress, the Al Shamal Cement Plant PV Power Project stands as a testament to human ingenuity and perseverance. It is a shining example of what can be achieved when innovation, determination and collaboration come together in pursuit of a common goal: a cleaner, brighter and more sustainable future for all.

Gratitude and vision

As we look back on our journey, we must acknowledge the many individuals and organisations whose contributions have made the Al Shamal Cement Plant PV power project a reality. From the engineers to the local staff and our partners, everyone has played an important role. This project sets a precedent for future renewable energy initiatives, emphasising innovation, collaboration and sustainability. Let it inspire us to push boundaries and create a better future.

www.gantner-environment.com